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(54) Efficient integrated circuit

(57) Novel algorithms for computing the responses of circuits to multi-tone excitations. The new algorithms are efficient and robust for large, strongly nonlinear circuits excited by multi-tone (quasi-periodic or envelope-modulated) signals. Hence they are particularly useful for integrated RF applications. The multivariate representation captures features produced by strong nonlinearities (such as spikes or pulses) much more compactly than traditional frequency- or time-domain representations. The new algorithms compute these functions efficiently by solving a partial differential equation (PDE) in the time or mixed frequency-time domains. Frequency-domain spectra or time-domain waveforms are generated from the multivariate functions as cheap post-processing steps. Two methods, multivariate FDTD and hierarchical shooting, are purely time-domain techniques suitable for the general strongly nonlinear circuit problem. They differ in their memory and computation needs. A new mixed frequency-time method is more efficient for circuits that are moderately (but not strongly) nonlinear in one or more tones (e.g, switching mixers, switched-capacitor filters). The linear systems at the core of all three techniques are especially well suited for iterative solution. This is exploited in the methods to achieve linear growth of computation and memory with respect to circuit size. The mixed frequency-time method of this work avoids the ill-conditioning problem by computing with the slow harmonic components directly, rather than with time-domain samples at sets of points close to each other.

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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 0404

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,A	MELVILLE R C ET AL: "Efficient multi-tone distortion analysis of analog integrated circuits" SANTA CLARA, MAY 1 - 4, 1995,NEW YORK, IEEE,US, vol. CONF. 17, 1 May 1995 (1995-05-01), pages 241-244, XP002102872 ISBN: 0-7803-2585-0 * the whole document *	1,10	G06F17/50
A	BRACHTENDORF H G ET AL: "Numerical steady state analysis of electronic circuits driven by multi-tone signals" ELECTRICAL ENGINEERING, APRIL 1996, SPRINGER-VERLAG, GERMANY, vol. 79, no. 2, pages 103-112, XP000965144 ISSN: 0003-9039 * the whole document *	1	
P,X	ROYCHOWDHURY J: "Efficient methods for simulating highly nonlinear multi-rate circuits" PROCEEDINGS 1997. DESIGN AUTOMATION CONFERENCE, 34TH DAC, PROCEEDINGS OF 34TH DESIGN AUTOMATION CONFERENCE, ANAHEIM, CA, USA, 9-13 JUNE 1997, pages 269-274, XP002153172 1997, New York, NY, USA, ACM, USA ISBN: 0-89791-920-3 * the whole document *	1-10	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 November 2000	Guingale, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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